Forestry Canada Forêts Canada

PROGRAM REVIEW 1988-89

NEWFOUNDLAND AND LABRADOR REGION

PROGRAM REVIEW
1988-89

FORESTRY CANADA
NEWFOUNDLAND AND LABRADOR
REGION

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FORESTRY CANADA

Forestry Canada is the main focus for forestry matters in the federal government. It provides national leadership through the development, coordination, and implementation of federal policies and programs to enhance long-term economic, social, and environmental benefits to Canadians from the forest sector.

Forestry Canada is a decentralized organization with six regional forestry centres, two national research institutes, and seven regional sub-offices located across Canada. Headquarters is located in the national capital region, in Hull, Quebec.

In support of its mandate, Forestry Canada carries out the following activities:

- Administers forest development agreements negotiated with the provinces.
- Undertakes and supports research, development, and technology transfer in forest management and utilization.
- Complies, analyzes, and desseminates information about national and international forest resources and related matters.
- Monitors disease and insect pests in Canada's forests.
- Provides information, analyses, and policy advice on economics, industry, markets, and trade related to the forest sector.
- Promotes employment, education, and training opportunities in the forest sector.
- Promotes public awareness of all aspects of the forest sector.

Forestry Canada interacts regularly with provincial and territorial governments, industry, labor, universities, conservationists, and the public through such bodies as the Canadian Council of Forest Ministers, the Forest Sector Advisory Council, the Forestry Research Advisory Council of Canada, the Canadian Forest Inventory Committee, the Canadian Committee on Forest Fire Management, the Canadian Interagency Forest Fire Centre, and regional consultative committees. Forestry Canada is also active in international forestry agencies such as the International Union of Forest Research Organizations and the Food and Agriculture Organization, as well as in technical and trade missions.

Forêts Canada

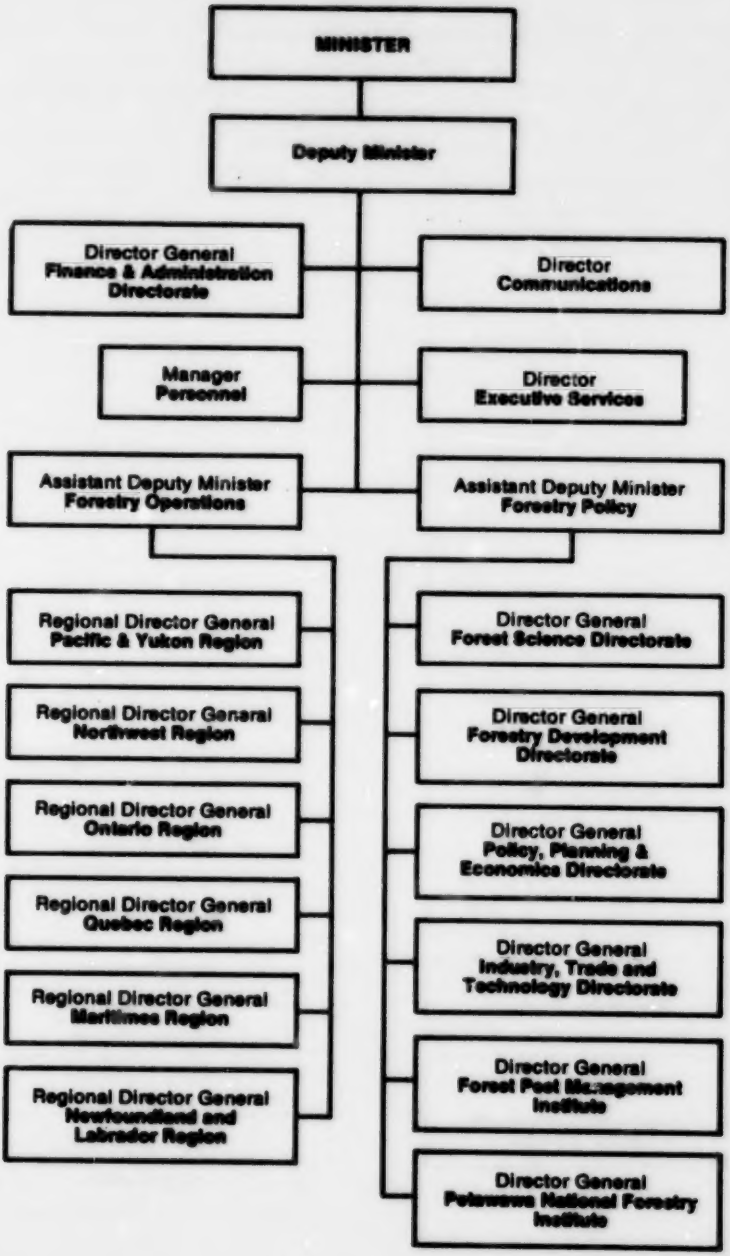
Forêts Canada est l'organisme principal en matière de foresterie à l'intérieur du gouvernement fédéral. Chef de file sur le plan national, il assure la préparation, la coordination et la mise en oeuvre des politiques et programmes fédéraux dans le but d' améliorer les avantages économiques, sociaux et environnementaux à long terme offerts aux Canadiens par le secteur forestier.

Forêts Canada est une organisation décentralisée: six centres de foresterie régionaux, deux instituts de recherche nationaux ainsi que sept sous-bureaux régionaux sont répartis dans tout le Canada. Le siège social est établi dans la région de la Capitale nationale, à Hull (Québec).

Pour remplir son mandat, Forêts Canada assume les tâches suivantes:

- il administre les accords de développement forestier conclus avec les provinces
- il entreprend et appuie la recherche, la mise au point et le transfert technologique dans le domaine de la gestion et de l'utilisation des forêts
- il rassemble, analyse et diffuse de l'information sur les ressources forestières nationales et internationales et les domaines connexes
- il fait des relevés des maladies et des insectes ravageurs des forêts canadiennes
- il fournit de l'information, des analyses et des conseils (quant aux politiques) concernant l'économie, l'industrie, les marchés et le commerce reliés au secteur forestier
- il favorise les occasions d'emploi et de formation universitaire et technique dans le secteur forestier
- il encourage les Canadiens à prendre conscience de tous les aspects du secteur forestier.

Forêts Canada entretient des rapports sur une base régulière avec les gouvernements provinciaux et territoriaux, l'industrie, le monde du travail, les universités, les environnementalistes et le public par l'entremise d'organismes comme le Conseil canadien des ministres des Forêts, le Conseil consultatif du secteur forestier, le Conseil consultatif de la recherche forestière du Canada, le Comité de l'inventaire des forêts du Canada, le Comité canadien de la gestion des incendies de forêt,le Centre interservices des feux de forêt du Canada et des comités consultatifs régionaux. Forêts Canada joue également un rêle actif dans des organismes internationaux de foresterie comme l'Union internationale des organisations de recherche forestière et l'Organisation pour l'alimentation et l'agriculture, de même qu'au sein de délégations de nature technique ou commerciale.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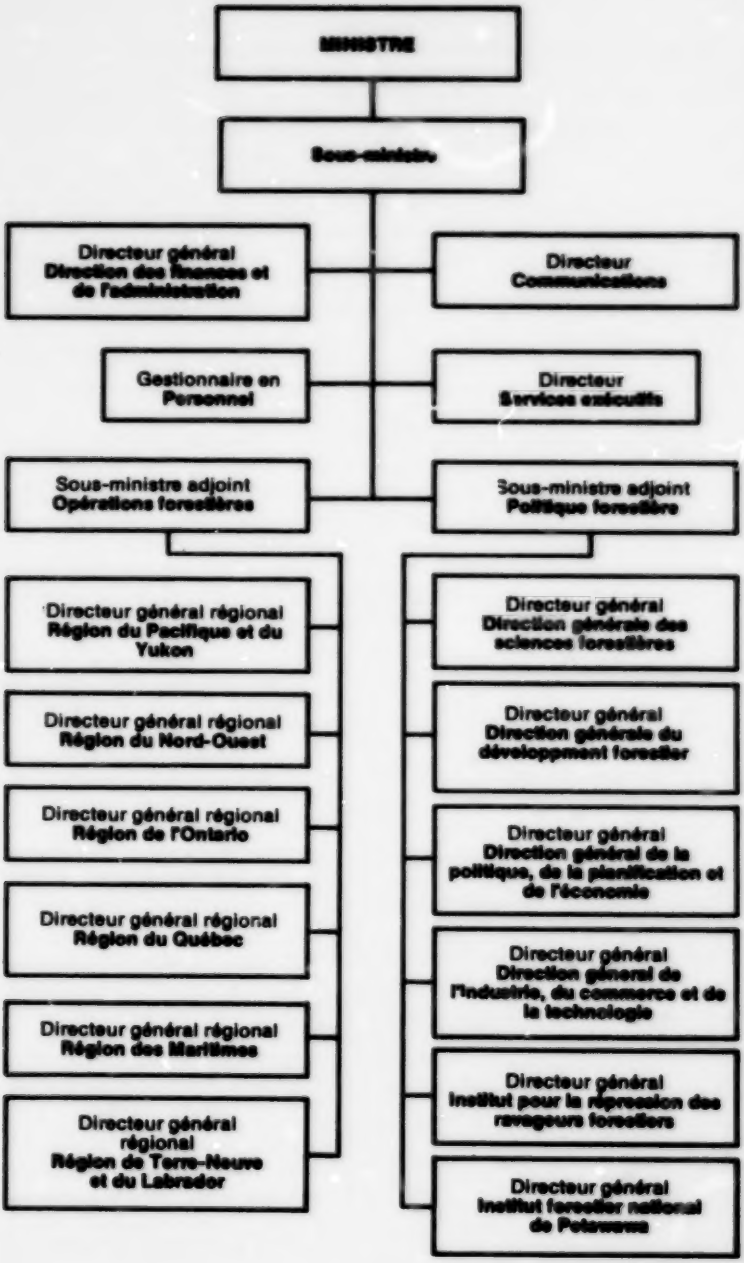
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Foreword

The past year was an active one for the staff of Forestry Canada in the Newfoundland and Labrador Region. It was also a time of organizational renewal here and throughout Forestry Canada generally as attention was focused on achieving excellence in client service through better management of our people or "human resources". In the next few years, increasing emphasis will be placed on developing an organizational environment that promotes the full development and participation of all members of our staff in the delivery of our programs.

Efforts to strengthen our research and development service to client agencies in the region were continued. In 1988 a new Memorandum of Understanding (MOU) on Forest Research was signed between the federal and provincial governments for the period 1988 to 1992. The MOU sets out the agreed upon priority areas for research for the respective forestry agencies of both governments and provides for the establishment of the Newfoundland Forest Research Advisory Committee (NEWFRAC) to coordinate activities. Memorial University and forest industry are represented on this committee as well as government agencies. The NEWFRAC committee held two meetings during the period under review, one of which included a field trip to Labrador to assess research needs there.

A major strategic planning exercise was also initiated in 1988. The objective was to improve our service to clients through development of a more focused research and development program in the region. A number of strategic forest sector issues were identified and ranked by 38 individuals representing a cross section of resource opinion in Newfoundland. The resulting strategic plan will be used by Forestry Canada managers as a guide in the development of program content and allocation of resources for the next five years.

The three main program areas of Forestry Canada in this region are Forest Resources and Environmental Research; Forest Protection Research; and Forestry Development. Highlighting our research program during this review period was an experimental spray program which resulted in the registration of a biological insecticide, *Bacillus thuringiensis (B.t.)* for use against the hemlock looper. This was a cooperative project among Forestry Canada, the provincial Department of Forestry and Agriculture, forest industry, and chemical companies. A study to identify the sex pheromone of the four-eyed spruce bark beetle was continued. An aggregation pheromone was discovered and field tested with positive results. Work is now

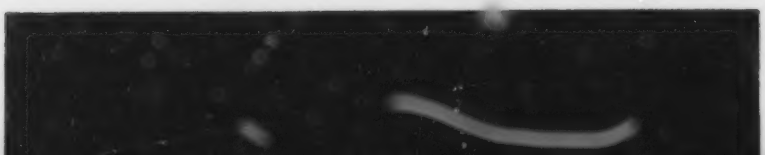
underway to develop an effective monitoring tool for the management of this pest. Forestry Canada, Memorial University, NORDCO Ltd. and the Provincial Department of Forestry and Agriculture worked together on a study to classify hemlock looper defoliation using satellite imagery. The study determined that satellite imagery was an effective tool giving 90 percent accuracy. Another federal/provincial cooperative project resulted in the preparation of a Forest Site Classification Manual. This publication, due for release in 1989-90, is an illustrated pocket-sized guide to aid field foresters in the identification and treatment of disturbed sites.

The Canada-Newfoundland Forest Resource Development Agreement which was signed in 1986, continued as the major activity of our Development Branch. Projects remained on schedule during 1988 and in some instances exceeded expectations. The Development Section was also heavily involved in the development of a silviculture training program targeted at the youth of the province. The program will be administered by our staff and funded through a cost-shared agreement between the Atlantic Canada Opportunities Agency, Employment and Immigration Canada, and the Newfoundland and Labrador Training Association.

The highlights noted above are a few of the projects being undertaken by our regional staff. The various sections of this booklet will provide you with a more detailed summary of programs. Please contact us if you require additional information.

J. Munro
Regional Director
General

PROGRAM MANAGEMENT



Program Management

Project 1111

Program Management

Project Leader: J.A. Munro

Objectives

To ensure efficient planning and management of the research and development activities; to ensure effective use of financial and personnel resources to achieve stated goals and objectives; to ensure that programs are responsive to the regional needs of client agencies and the national concerns of the Government of Canada.

Achievements Current Year

Overall direction was provided for all programs. Staff training needs were identified and special efforts were made to promote French Language Training. A new five year strategic plan for regional plans was developed.

Goals for 1989-90

Continue to provide overall direction and control of Forestry Canada operations in the region. Continue to improve the quality of human resource management by appropriate staff training and development courses.

FINANCE AND ADMINISTRATION

Finance and Administration

Project 1211/1221

Financial and Administrative Services

Project Leader: R.J. Angel

Objectives

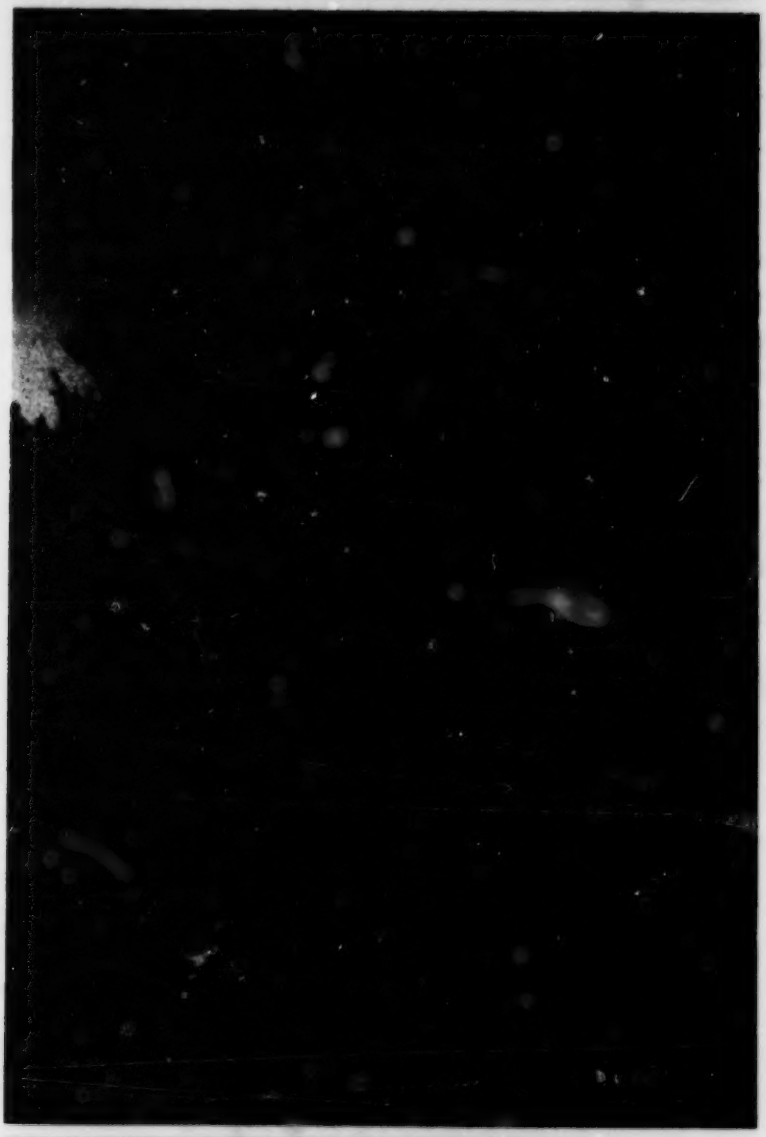
To provide financial, consulting and advisory services to regional management; to ensure adequate internal control of finances, provide a complete range of accounting services and maintain adequate accounting records; to administer the financial controls on federal-provincial development agreements and job creation programs.

Achievements Current Year

The material management information system was fully implemented in 1988-89. Additional renovations were made to research and laboratory facilities in the regional office in Pleasantville and field stations at Pasadena, Badger, and North Pond were upgraded under the minor construction program. Effective financial administration of the Canada-Newfoundland Forest Resource Development Agreement (FRDA) was continued by finance staff.

Goals for 1989-90

To provide financial and advisory service to regional management and other system users. To provide effective administrative services to all segments within the region. To continue upgrading facilities under the Minor Capital Construction Program. To provide effective financial control of the FRDA.



FOREST RESOURCES AND ENVIRONMENTAL RESEARCH

Environmental Assessment of Forestry Practices

Project 2211
Environmental Assessment of Forestry Practices
Project Leader: I.D. Thompson

Objectives

To determine impacts of forest management practices on terrestrial systems; to assess the impacts by moose on second growth forest and pre-commercially thinned stands; to determine the impacts of timber harvesting on carrying capacity of the forest for wildlife species; to provide guidelines for multiple use forestry; to provide advice to other government agencies as requested.

Achievements Current Year

Chemical composition including secondary compounds was completed for balsam fir from spaced and unthinned stands. A second spacing trials, on the west coast, was assessed for browsing damage by moose, completing the study of the impacts of moose on balsam fir regeneration. Species composition and ground truthing of habitat classes begun as the initial stage towards developing a carrying capacity model for moose. Twig production and nitrogen content of balsam fir growing with alder was assessed. Papers were published on moose/balsam fir interactions and the impacts of forestry on furbearers.

Goals for 1989-90

To measure the nitrogen content of white birch twigs as a winter forage for moose. To determine the density of white birch in roadside habitats and measure leaf production. To measure the production of herbaceous forage in alder communities in order to develop predictive equations for biomass production by species and for the community.

List of Studies

Service to other agencies
Leader: I.D. Thompson

Impact of forestry practices on wildlife
Leader: I.D. Thompson

Effects of moose on forest regeneration
Leader: I.D. Thompson

Forest and Plant Ecology

Project 2214
Forest and Plant Ecology
Project Leader: W.J. Meades

Objectives

To develop intensive baseline data on the composition of forest, heathland, and peatland habitats both before and after forestry activities; to develop a better understanding of ecological factors controlling tree growth on peatlands with a view to future afforestation potential; and to cooperate with industry and government agencies in the application of forest and land classification technology to forest management decisions.

Achievements Current Year

A draft site classification manual for Newfoundland was completed in cooperation with the provincial department of Forestry and Agriculture with funding from the Canada-Newfoundland Forest Resource Development Agreement. A chapter on The Wetlands of Eastern Canada was published in the book Wetlands of Canada Committee on Ecological Land Classification. A 70 K UPI contract was established with Northland Associates Ltd. initiated to accelerate studies on cutover vegetation in central Newfoundland. A review of site classification activities in this region was submitted to the SCALE Working Group as part of a national review to be published in Forestry Chronicle. A poster presentation on the "Nutrition and Growth of Red Pine" was presented at the 7th North American Forest Soils Conference.

Goals for 1989-90

Monthly seedfall data and year three permanent plot re-measurements will be conducted on the black spruce cutover succession plots in central Newfoundland. Permanent vegetation plots will be photographed for comparison with year one plots. Vegetation classification of unmanaged cutovers will be completed in the 1989 field season and a contract will be awarded for similar studies in central Newfoundland. A site classification manual will be published in cooperation with the Provincial Department of Forestry and Agriculture. To complete the second survey of the red pine cone and seed study and publish a report of the first study. To re-sample red pine foliage after fire for nutrient determination. To present two posters on ecology of white spruce. Prepare journal note on white spruce. To continue work on thesis "The establishment of early growth of trees on drained peatlands in Newfoundland." To present a paper at the Peat and Peatland Conference in Quebec. To present a poster at Forest Research Marketplace, Toronto.

Conducting a regeneration survey on a study area.

List of Studies

Ecological investigations of wetlands for forestry
Leaders: E.D. Wells, S.M. Morgan

Ecological investigations of heathlands
Leaders: W.J. Meades, A.R. van Kesteren

Forest classification, ecology, and mapping
Leaders: W.J. Meades, A.R. van Kesteren

The growth characteristics and ecology of larch, white spruce and red pine in Newfoundland
Leader: B.A. Roberts

Reforestation

Project 2222
Reforestation
Project Leader: B.D. Titus

Objectives

To assist forest managers to maximize the success of their reforestation programs: by developing methodologies for the efficient and accurate identification of sites requiring silvicultural treatment; by quantifying the effects of mechanical site preparation on microsite properties, and resultant seedling response; by quantifying the growth of different planting stock types on different sites; by enhancing productivity through exploiting genetic variation; by quantifying the response of conifers to release from competing vegetation.

Achievements Current Year

A study suggesting the allelopathic compounds influence black spruce establishment was completed. A fixed-precision list-quadrat sequential sampling plan for estimating black spruce and balsam fir point-densities on recently disturbed sites was developed for operational use. The temporal and spatial establishment patterns, subsequent size hierarchy development, and competitive relationships within second-growth black spruce stands were described. Mechanical site preparation trials were assessed for two year growth and survival. Pre-treatment vegetation survey of Kalmia reforestation trial was completed. Cones were collected from range-wide provenance (seed source) tests of black spruce, white spruce and Sitka spruce to assess variation in seed production and quality.

In addition, a new scientist was hired in 1988 to fill the vacant forest genetics research position in the Newfoundland Region. A project review was held in February 1989 to cover the period 1982-1989. National Program Assessments for Genetics and Reforestation took place. B.D. Titus chaired and P.F. Newton sat on the organizing committee for the IUFRO Working Party S1.05-12 Annual Symposium, held 12-17 August 1989 in Newfoundland.

Containerized black spruce seedlings.

Goals for 1989-90

Complete black spruce intraspecific competition data analysis. Complete eight year height assessments on Planting Stock Comparison and Quality trials. Complete three year height and survival assessments on mechanical site preparation trials. Monitor microenvironment on mechanical site preparation trials. Complete mechanical and chemical site preparation treatments on Kalmia reforestation trials. Process seed for genetics studies. Establish isoenzyme laboratory facility.

List of Studies

Competition control on forest sites
Leader: B.D. Titus

Regeneration assessment
Leader: P.F. Newton

Plantation Research
Leaders: B.D. Titus, V.D. Chaffey

Site preparation research
Leader: B.D. Titus

Population genetics and tree improvement
Leader: A.J. Mosseler

Reforestation of sites dominated by Kalmia
Leader: B.D. Titus

Tree and Stand Growth

Project 2223
Tree and Stand Growth
Project Leader: M.B. Lavigne

Objectives

To examine and assess the ecological and physiological processes involved in tree growth and stand development as a basis for incorporating site and stand factors, and silvicultural practises into growth and yield models; to cooperate with other forest agencies in this province in setting out silviculture field trials for the purpose of producing good quality growth and yield data in the future.

Achievements Current Year

A report was published about the effects of spruce budworm defoliation on the response of black spruce to precommercial thinning. Diameter distributions of black spruce and balsam fir grown in pure stands and mixed stands were compared in a journal paper. An evaluation of the self-thinning rule for use in yield models of black spruce was completed. Field and laboratory work continued for investigations of intraspecific competition. Five spacing trials in precommercially thinned stands of black spruce and balsam fir were remeasured by the provincial Department of Forestry and Agriculture. Laboratory work for growth analysis of balsam fir from the Cormack spacing trial was completed. The analysis of the plot remeasurements of the Cormack spacing trial was completed and a manuscript was prepared for review. A paper was published reporting the relationship between stem respiration rate and stem growth rate. A report comparing the net assimilation rate and related processes of thinned and unthinned balsam fir stands was published. The trenching/fertilization experiment was maintained by refreshing trenches and fertilizing. Photosynthetic rates of trees in this experiment were measured. Data on moisture relations of balsam fir and black spruce trees were analyzed. Assistance was provided to the provincial Department of Forestry and Agriculture with their use of wood supply models for management planning.

Goals for 1989-90

To continue data collection for study of intraspecific competition. To publish programs for analyzing stem analysis data. To publish base-age invariant polymorphic site index curves for central Newfoundland. To publish the analysis of the self-thinning rule. To complete the assessment of interspecific competition between balsam fir and black spruce. To remeasure a spacing trial. To analyze the remeasurement data for five spacing trials. To analyze and publish the results of growth analysis in a balsam fir percommercial thinning spacing trial. To publish a paper on the allocation of growth among components in thinned and unthinned balsam fir stands. To maintain the trenching/fertilization field experient.

List of Studies

Influence of stand density and fertilization on productivity of natural and planted softwoods.
Leader: M.B. Lavigne

Tree and stand growth prediction
Leader: M.B. Lavigne

Development of stand density management models
Leader: P.F. Newton

Energy From the Forest (ENFOR)

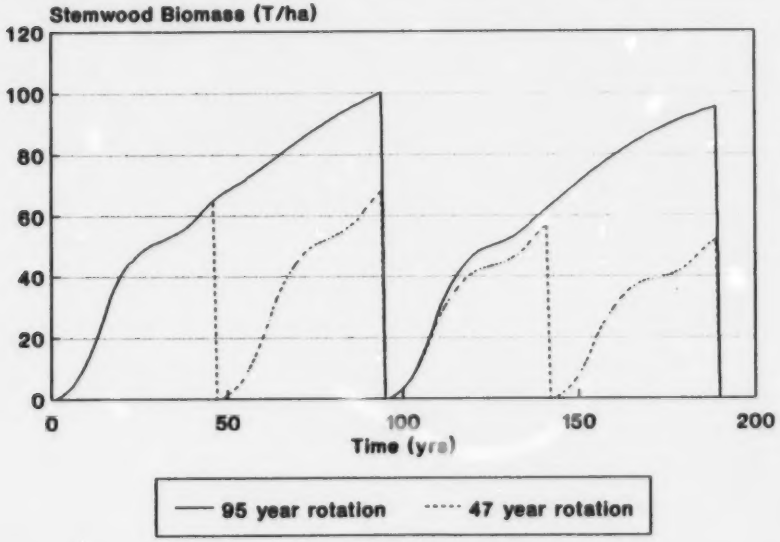
Project 2241
ENFOR
Project Leader: R.S. van Nostrand

Objectives

To determine the technical and economic feasibility of using forest biomass for energy production in Newfoundland. To assist the Department of Forestry and Agriculture in developing long term strategies for the utilization of biomass for energy. To cooperate with DFA in developing methods and techniques for biomass inventory and management. To assess environmental impacts of biomass harvesting and methods of reforestation.

Achievements Current Year

P-172 - The *Salix* energy plantations were maintained and one hectare of new plantation was established. Baseline biometeorological data were collected from two sites using the energy balance systems. One new energy balance system was built and is to be loaned to the Iceland Government for a cooperative energy plantation project. The Department of Forestry and Agriculture has agreed to assist in establishing trials of *Salix* plantations to further assess the potential of energy forests. **P-264** - Calibrating and testing of FORCYTE-11 model continued. Additional data on biomass of white birch was collected to complete the calibration of the model. **P-362** - Results of an economic analyses of the competitive position of fuelwood from prepared energy plantations in Newfoundland, was published. **P-363** - A review of forest biomass fuel used for energy in Newfoundland, was published.



Goals for 1989-90

P-172 - To involve the Department of Forestry and Agriculture in establishing energy plantations. To establish an energy balance system in Iceland as part of a cooperative project on energy plantations. To conduct additional energy balance studies. **P-264** - To complete calibration and testing of the FORCYTE model and prepare reports on calibration and evaluation. **P-385** - Establish a new study on the environmental impact of whole-tree harvesting of white birch for fuelwood.

List of Studies

Reforestation after whole-tree chipping for hog fuel
Leader: B.D. Titus

Boreal energy plantation R&D
Leader: A.W. Robertson

Calibrating the FORCYTE growth model for Newfoundland forest types
Leader: W.J. Meades

Forest biomass energy use in Newfoundland
Leader: G.R. Milne

Impact of whole-tree harvesting of white birch stands
Leader: B.A. Roberts

Environmental Influences on Forest Growth

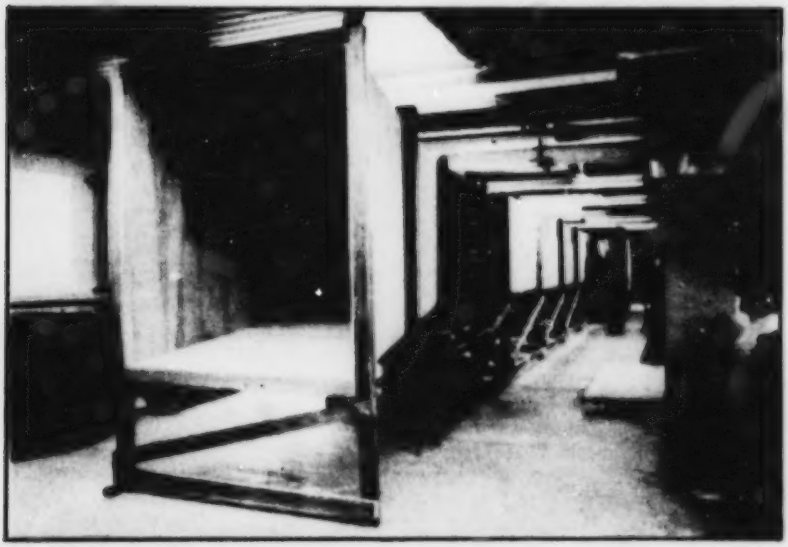
Project 2213
Environmental Influences on Forest Growth
Project Leader: A.W. Robertson

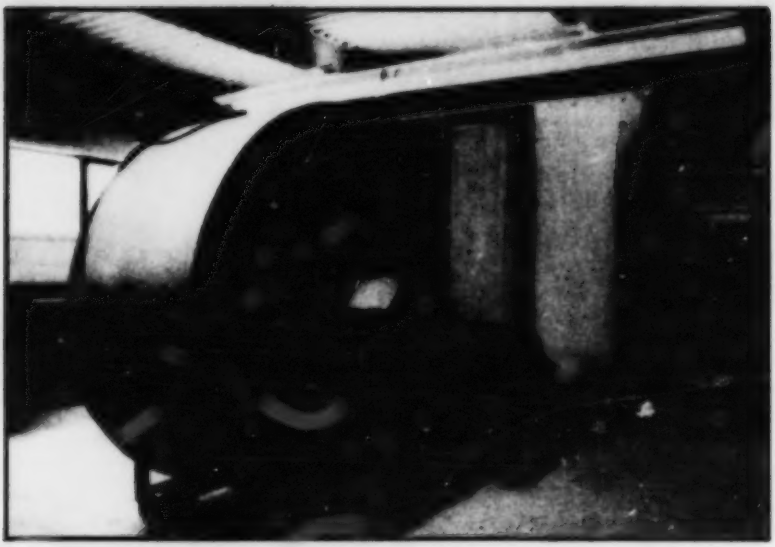
Objectives

To conduct biometeorological research aimed at quantifying energy fluxes in forest ecosystems and conducting to estimate the amount of available energy for growth on specific sites and establish plantations and experimental cutting patterns designed to increase the amount of energy stored in biomass; to provide a detailed assessment of how mesoscale and micro-scale wind flow restricts forest development in plantations and natural forests and develop an exposure rating system for incorporation into site classification schemes; to establish demonstration plantations, thinning and cutting patterns to improve productivity and/or prevent rapid deterioration in residual forest stands following cutting. Act as focal point for information and technology transfer of research and technology trends pertaining to the effect of climate change on forestry.

Achievements Current Year

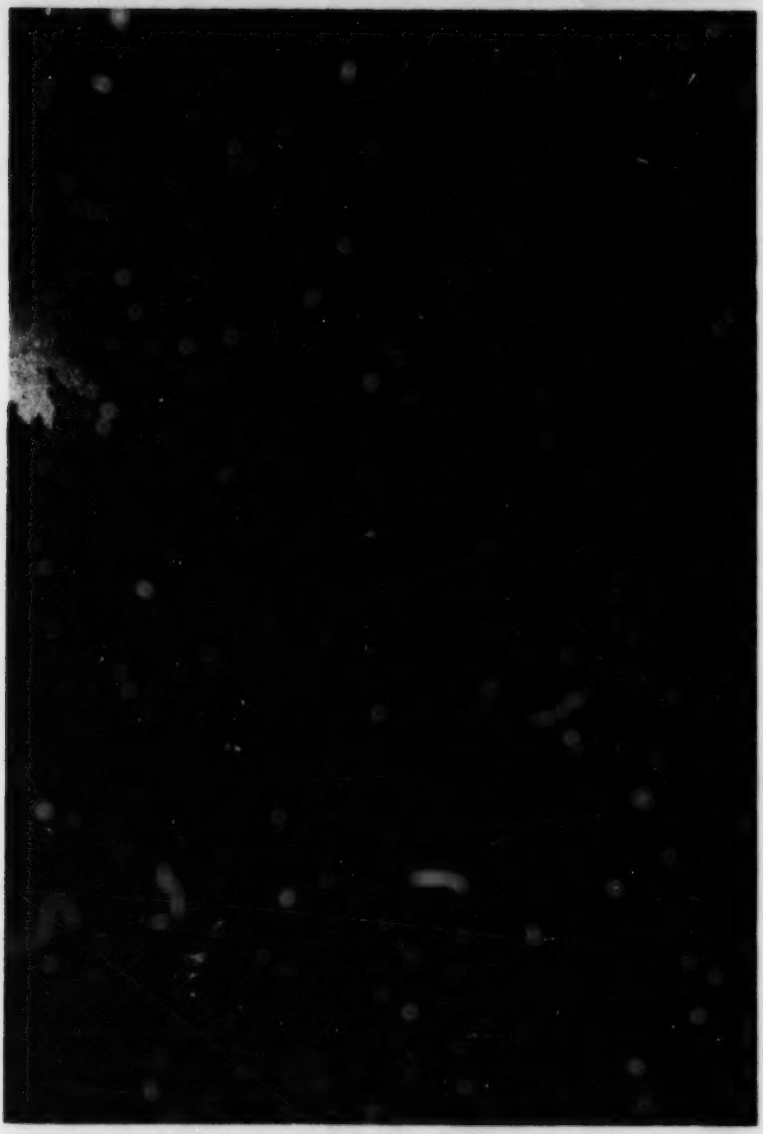
The first studies of the energy balance of forest cutovers in Newfoundland were initiated. A simple regression model using trees to estimate mean wind speed was developed and tested. Experiments on flow visualization of wind flow in forests were conducted and used for public/professional demonstration. An amphi-Atlantic survey of wind effects on forests was published in two European journals. The first Island-wide compilation of soils was completed and published as a monograph. Studies on seepage soils and the chara ristics of various types of soil humus were initiated.





Goals for 1989-90

To analyse and publish preliminary results of the energy balance studies at St. Georges and Salmon Pond and conduct energy balance measurements at St. Georges and Black Duck in western Newfoundland, Gunnersholt in Iceland and in a greenhouse in Mount Pearl. Conduct exploratory fluid visualization study for forestry applications at the Marine Institute's circulating water channel. To begin chemical analyses of 500 humus samples from Kalmia dominated sites. To publish book chapters on uptake of metals by plants on selected sites. To complete field work on flooded sites and obtain seepage data from the Churchill Falls watershed.



FOREST PROTECTION RESEARCH

Pest Biology Research

Project 2232
Pest Biology Research
Project Leader: A.G. Raske

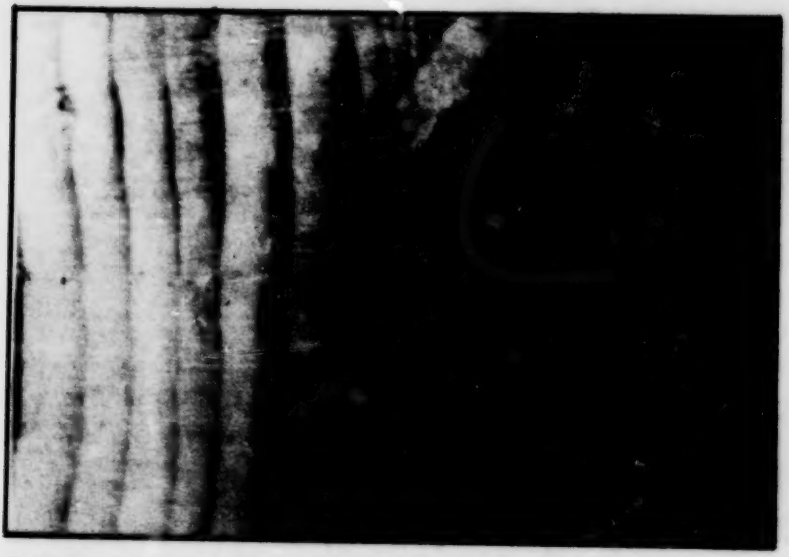
Objectives

To develop effective and practical methods for measuring population levels of forest pests and their natural control factors; to investigate the biology of pest insects and diseases including their population dynamics; to assess insect and disease impacts on major age classes of forest trees and stands; to develop methods to prevent or minimize forest losses.

Achievements Current Year

This project encompasses a wide variety of research activities of forest insects, forest diseases, and also includes research on the damage by the introduced red squirrel.

Germination tests of seeds from insect-damaged cones continued as well as studies on seed losses caused by red squirrel predation. Squirrel distribution studies have also related cone losses to density of squirrels. In general when the cone crop is small, squirrels will destroy a large proportion of the crop. But when the cone crop is large, squirrels will harvest only a small proportion of the total crop.



Reduced growth rings of balsam fir caused by spruce budworm defoliation.

Studies on sampling, ecology and control of the black army cutworm, *Actebia fennica*, started in 1986. Permethrin applied from the ground gives good control of larvae, but materials that can be sprayed from the air are being investigated.

Ground application of a virus (Virtuss) to a white-marked tussock moth, *Orgyia leucostigma*, infestation was generally successful in that larval populations were reduced several weeks after treatment, but prevention of defoliation was not achieved. Second-year effects of the Virtuss applications included virtual elimination of the white-marked tussock moth from treated areas.

Scleroderris canker, *Gremmeniella abietina*, was isolated from Sitka spruce in a plantation near Roddickton. The canker was also discovered outside the quarantine area in an old tree nursery on the Salmonier Line and in a Scots pine plantation on the Avalon Peninsula. The magnitude of the problem is being assessed by surveying plantations throughout Newfoundland.

Studies on the deterioration of balsam fir damage by the spruce budworm were completed. Rate of decay is much slower if wood wasps (Siricidae) introduce the fungus, *Amylostereum chailletii*, than if bark beetles invade the tree and introduce the decay fungus, *Hirschioporus abietinus*. In general there is a low percent of saprot deterioration in black spruce because of the rapid drying of wood in stands with high mortality.

Tree mortality and deterioration of hemlock looper killed balsam fir stands was always greater than 70 percent. The community structure of causal decay organisms in tree deterioration is being studied.

Tables on gross and net merchantable volumes, by management unit, have been updated for wood density and identification of decay causal organisms. Work is

Secondary insects and their associated fungi play an important role in the rates and types of sapwood deterioration of insect killed balsam fir; left-siricid woodwasp and ovipositon punctures

continuing on the stratification of the Province into natural forest regions based upon gross and net merchantable volume figures and wood density. Susceptible cull regions are being researched based upon heartrot and buttrot fungal isolations.

The recent increase in balsam woolly aphid damage in western Newfoundland was jointly inspected by all forest agencies. The balsam woolly aphid was decidedly more abundant and damage more severe in young stands recently thinned than in adjacent unthinned stands.

Juvenile hormones were sprayed against the balsam woolly aphid and significant population reduction of sessile nymphs occurred following treatment with some formulations.

Estimates of larval and pupal mortality continue to round out the knowledge of population dynamics of the spruce budworm and the hemlock looper. At low population levels of spruce budworm parasites and diseases usually cause between 10% and 30% mortality for the spruce budworm. However for the hemlock looper, mortality for these life stages by parasites, and especially diseases can be much higher; approaching 90% locally.

Data on the within-tree distribution of hemlock looper eggs has been collected and sample units determined. A dynamic sequential simulation model has been constructed to forecast looper defoliation.

The first versions of four models have been produced that will form a user friendly Pest Management Support system for the eastern hemlock looper. The models assess the risk of when a looper outbreak will develop, where it will develop and how it will spread, the impact of the outbreak in tree mortality and predict within-generation development based on degree-day accumulation.

Balsam fir bark beetle and its nuptial galleries.

Carrying tree samples from plot used to determine volume loss caused by spruce budworm defoliation.

Impact plots are measured annually for budworm population levels and severity of damage and trees have been cut for growth loss analysis. Data have been analyzed by differences of degree of damage received and analyses are continuing. Software has been adapted to assess impact of defoliation on growth. Growth loss curves for selected trees in light, moderate and severe categories of cumulative spruce budworm damage have been determined.

Permanent sample plots in fir regeneration were monitored for budworm damage. Data will be used to develop a model to forecast crown development following budworm damage. Several young balsam fir were artificially defoliated and other young fir trees were defoliated by spruce budworm larvae placed on the branches. These trials measured the effect of defoliation on growth with greater precision that has not been possible up to now.

Foliage loss per branch caused by 5th and 6th instar spruce budworm larvae feeding has been determined. A damage function relating stemwood increment growth loss as a function of defoliation intensity has also been determined for immature, even-aged balsam fir stands.

The experimental spray program against the hemlock looper continued with 15 treatments testing various formations of *B.t.* or diflubenzuron. Only single application of all treatments were tested. Treatments of the oil-base formulations (Dipel) of *B.t.* provided better larval reductions and foliage protection than did the water-base formulations (Futura XLV) of *B.t.* Diflubenzuron reduced larval numbers but provided little foliage protection, because larvae were killed only in the late feeding stages.

Tree ring measuring laboratory. Tree rings are projected onto a high resolution TV screen and measurement transferred to a computor for tree volume analyses.

Goals for 1989-90

Studies on seed and cone pests and plantation pests will continue with the new emphasis they received in recent years. Germination tests of damaged cones by various agents will continue as will the study on the impact to red squirrel populations on the cone crop of black spruce trees. Chemical control attempts with systemic insecticides will be included in studies on the spruce bud midge.

Plans are to expand the research on various aspects of the balsam woolly aphid problem; especially in recently thinned stands. The sampling system will be refined for young stands, and its ecology studied in such stands. Practical control methods will be investigated with new juvenile hormones that work well with other aphid species.

Investigations into the deterioration of insect-killed trees will continue to form a part of the research program. Studies on spruce budworm killed fir will be published and those on black spruce are nearly completed. A major program will be started to study the mycorrhizal enhancement of growth of black spruce seedlings. The identification of natural cull regions in Newfoundland will be a great aid to forest harvesting operations.

A few studies remain on the ecology and impact of the four-eyed spruce bark beetle. These will emphasize integrated control strategies. Publication of results will be a major accomplishment in the next few years.

Population dynamic studies of the spruce budworm and hemlock looper will continue even for endemic population levels of these defoliators. Such studies will enhance our accumulated data base. Impact studies on these defoliators will also continue on various aspects on tree mortality and growth-loss. Data on the impact of the spruce budworm on forest succession will be analyzed for publication and plots will be remeasured in the early 1990's.

Exension ladder on trailer used for cone studies.

If outbreak populations of the hemlock looper persist our studies to refine control strategies will continue. Emphasis will be placed on developing control methods other than the use of chemicals.

Staff at the Newfoundland and Labrador Region plan a major effort to identify the sex pheromone of the hemlock looper, which includes a cooperative project with Simon Fraser University. The use of a pheromone could aid in detecting impending outbreaks and provide lead time to plan preventative control strategies.

List of Studies

Factors damaging to cone crops
Leader: R.J. West

Plantation and regeneration pests
Leaders: R.J. West, G.R. Warren

Balsam woolly aphid
Leader: E.J. Dobesberger

Armillaria root rot
Leader: Vacant

Deterioration of insect-damaged trees
Leader: G.R. Warren

Decay and wood quality of living trees
Leader: G.R. Warren

Role of woodborers and bark beetles in tree mortality and deterioration
Leader: W.W. Bowers

Population studies of major defoliators
Leader: E.J. Dobesberger

Biocontrol factors of major defoliators
Leader: K.P. Lim

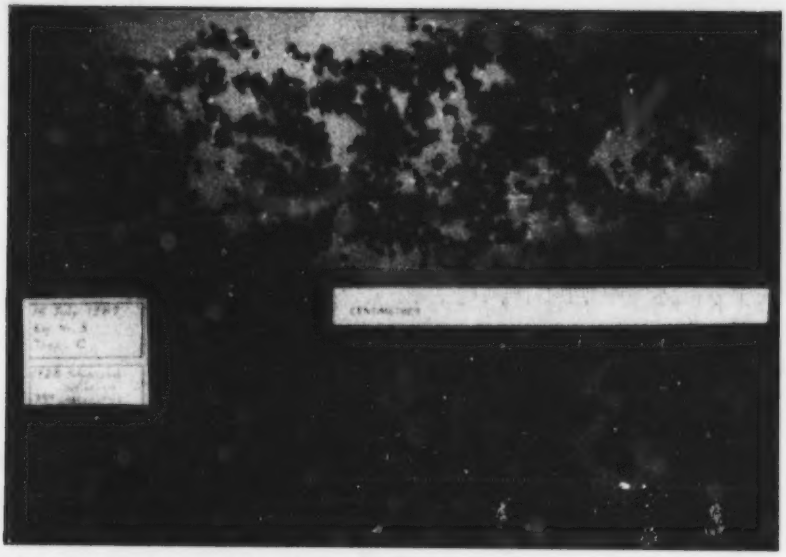
Impact of major defoliators
Leaders: A.G. Raske, E.J. Dobesberger

Impact of spruce budworm on forest succession in Newfoundland
Leader: W.J. Meades

Effectiveness of insecticides
Leaders: A.G. Raske, R.J. West, K.P. Lim

Sex pheromone(s) of the eastern hemlock looper
Leader: K.P. Lim

Recording calling behaviour of hemlock looper moths.



Beetle and predator attracted to pheromone trap.

Top dieback and associated stem defects resulting fron insect defoliation of young balsam fir stands.

Biological Control Research

Project 2234
Biological Control Research
Project Leaders: P.L. Dixon, K.P. Lim

Objectives

To develop effective biological control of forest insect pests; to investigate the potential of parasites, fungi and nematodes in biological control; to evaluate the effect(s) of chemical insecticides on parasites of forest pests.

Achievements Current Year

Mountain-ash sawfly larvae were collected from about 100 sites in the St. John's area and dissected to determine the rate of spread of the introduced parasite *Olesicampe geniculatae*. Parasitism ranged from 0-80% depending on distance from the release site at Oxen Pond Botanic Garden. Birch casebearer samples collected near Gambo indicate the introduced parasites, *Apanteles* spp., is spreading slowly. Parasitism was 97% at the release site and 6% at approximately 8 km distant. Casebearer-infested branches with parasites were relocated to Millertown, Badger, and Pasadena to assist the natural spread of the parasite. A nuclear polyhedrosis virus was applied to all known infestations of the European pine sawfly, and this virus was very effective in eliminating these infestations.

Cocoon of European pine sawfly.

Studies continued on the parasitic fly *Winthemia occidentis*, which was introduced to help control the hemlock looper. Ten Malaise traps were operated at five locations across Newfoundland; including fenitrothion-treated spray blocks on the Northern Peninsula. Trap catch data provides information on the presence or absence of this parasite in the field during spray time. Several hundred of this tachinid parasite were reared in attempts to establish a laboratory colony needed for detailed ecological work.

Goals for 1989-90

To continue monitoring the spread of introduced parasites, and to introduce another parasite, *Agathis cinta*, against the birch casebearer. To continue lab and field studies on *Winthemia occidentis*, and research on the use of entomogenous nematodes and fungi against forest pests.

Spruce budworm larvae infected with a fungus.

List of Studies

Populations of introduced biological control agents
Leader: P.L. Dixon

Control of forest insect pests with nematodes and fungi
Leader: P.L. Dixon

Insecticides and parasitoids of the hemlock looper
Leader: P.L. Dixon

FIDS (Forest Insect and Disease Survey)

Project 2311
FIDS (Forest Insect and Disease Survey)
Project Leader: J. Hudak

Objectives

To conduct annual surveys of forest pest conditions, determine the extent of infestations, assess impact, forecast impending conditions, and recommend control measures; when necessary evaluate the effectiveness of direct control measures; to provide forest pest data and related information for the National Forest Resource Data Program of Canada and other national and regional reports.

Achievements Current Year

The hemlock looper continued to be the most damaging insect, causing moderate and severe defoliation on about 12 900 ha and light defoliation on about 4 700 ha. About 1300 ha occurred on the Avalon Peninsula and the remainder along the west coast of the Island. FIDS staff cooperated in an experimental spray program testing the effectiveness of new formulations and dosages of *B.t.* and diflubenzuron; an insect growth regulator. Sampling determined the rate of parasitism and fungal diseases to average 13% and 33% respectively in the older parts of the infestation and 1% and 5% in the newer infestations. Tree mortality was more than 90% in most stands severely defoliated in 1986 or in 1987. About 10 500 ha of moderate and severe defoliation were forecast to occur in 1989 and all of this on the Northern Peninsula.

Population levels of the spruce budworm decreased and only 270 ha of defoliation occurred in the Codroy River Valley. The number of male moths trapped in pheromone-baited traps was very low in 1988, and moths were trapped only in western Newfoundland. A sample of overwintering larval numbers indicate an increase in area of defoliation can be expected in 1989, with 1 200 ha forecast.

The blackheaded budworm caused severe defoliation of overmature fir stands on the Northern Peninsula and about 3 700 ha were affected. The infestation is likely to continue in 1989 because the rate of parasitism was low at 5%.

The area of infestation by the balsam woolly aphid continued to increase in Newfoundland with over 160 000 ha infected. The black army cutworm infested over 2000 ha of regeneration causing severe damage to black spruce seedlings in several plantations.

Surveys of tree-inhabiting nematodes continued, with special emphasis in Labrador, and to extend the known range of the benign form of the pinewood nematode. Possible insect vectors of the pinewood nematode were surveyed across the province, but all vectors sampled did not contain this nematode.

All Sitka spruce plantations were sampled for Scleroderris canker, but no additional plantation was found to be infected. Therefore the plantation at Roddickton remains the only affected area outside of the Avalon Peninsula.

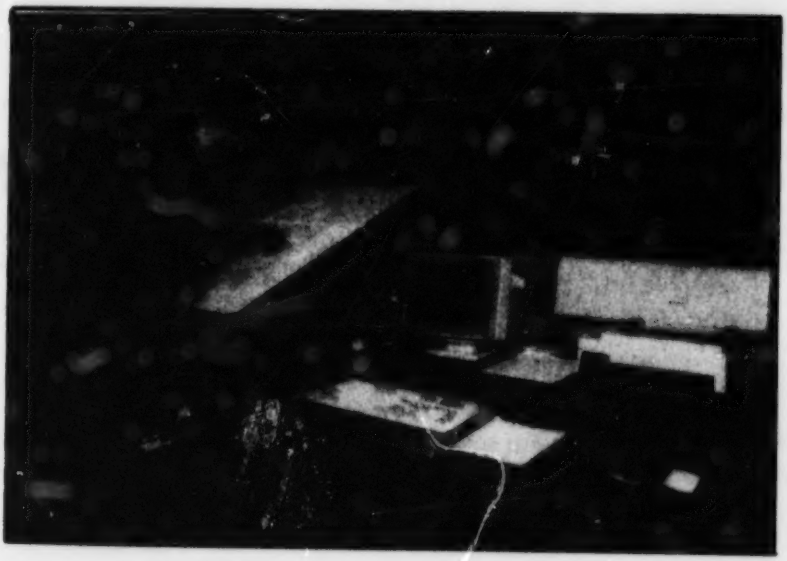
Calibrating sprays of suspensions of nematodes.

FIDS cooperated in the contract to demonstrate the feasibility of using high resolution, multispectral satellite data, generated by advanced image processing techniques, to delineate hemlock looper defoliation. Both SPOT and LANDSAT TM imagery delineated areas of hemlock looper defoliation with accuracies in excess of 90% based on field checks of infested areas. Three defoliation classes (light, moderate and severe) were delineated using the SPOT images. Results were transferred to provincial GIS in digital form. This is the first time that forest pest information from satellite imagery was transferred to forest inventory data in digital form.

Goals for 1989-90

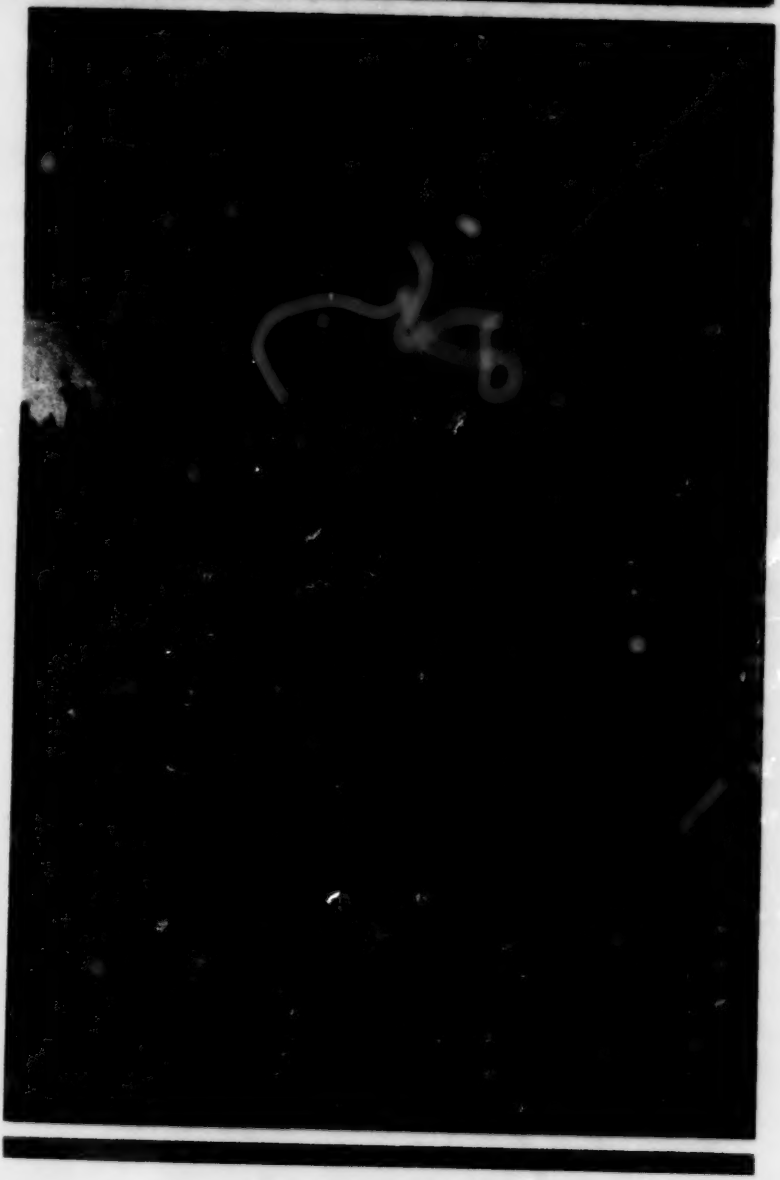
To continue to provide extensive and detailed forest pest information for all major and most minor pests to all client agencies and for national programs. This information includes pest densities, geographical distribution, defoliation and other damage estimates, impact assessment and forecasting extend and severity of serious pest conditions. The Forest Insect and Disease Survey will continue to provide technical advice, instructions and when necessary evaluate effectiveness of control measures.

Inspecting Ips beetle infested white spruce.



Geographic Information System.

Assessing tree defoliation.



FORESTRY DEVELOPMENT

Program Management

Project 3111
Program Management
Project Leader: J.M. Butler

Objectives

To provide management and common support services to the Forestry Development Branch, Newfoundland and Labrador Region; to recruit and train appropriate staff to discharge the development responsibilities of the branch.

Achievements Current Year

The Program Director successfully completed a three-week management training course. In addition, two contracts were let to provide professional services in support of the Canada-Newfoundland Forest Resource Development Agreement.

Goals for 1989-90

To continue to provide Management support for the unit.

Canada-Newfoundland Forest Resource Development Agreement

Project 3212
Canada-Newfoundland Forest Resource Development Agreement
Project Leader: J.M. Butler

Objectives

Through the three main Agreement Programs: Forest Resource Management, Research and Development, Opportunity Identification and Technology Transfer, and Administration, Communications and Evaluation, continue to support intensive forest management initiatives in Newfoundland. The main focus will be on correcting predicted future timber shortages, thereby ensuring future employment opportunities in the forest sector.

Achievements Current Year

In 1988-89, approximately $13.8 million was spent on Agreement activities. This was dispersed over the three main programs. Major achievements for the third year of the Agreement include the silviculture treatment of approximately 12 800 ha of forest land; the construction of 61 km of forest access roads; the continued expansion of the Geographic Information System; and the continuation of support to the Forest Insect and Disease Survey Program. Research and Development was also carried out in silviculture, forest industry development, forest inventory and forest insect control.

Through the FRDA Forest Products Technology Transfer Program, new woodlot harvesting and transporting equipment was demonstrated to potential users.

Goals for 1989-90

Targeted expenditures for 1989-90 total $14.8 million. Included in this are the treatment of approximately 14 000 ha of forest lands, the construction of 38 km of forest access roads, and the expansion of the GIS. In addition, research and development projects will proceed in the fields of silviculture, forest inventory, forest products and forest protection. The private woodlot management pilot project will continue with the development of woodlot management plans. Technology transfer programs aimed at forest product development, improved road building techniques and introducing new silviculture technology to the Province will continue. In addition, work will proceed on the development of a timber supply model for the Province. Continued emphasis will be placed on human resource development through educational training. Finally, efforts to raise the public awareness of forestry in the province will be maintained through the public relations program.

Development Program Directors from across the country met in Newfoundland this past summer. While here, field visits were conducted.

List of Studies

Forest Renewal
Forest improvement
Forest access roads
Forest management and inventory
Forest fire management
Insect and disease protection
Research and development
Opportunity identification
Technology transfer
Federal administration
Federal and provincial communications
Human resource development
Economics and agreement coordination
Evaluation

Agreement Administration

Project 3251
Agreement Administration (ForCan Resource)
Project Leader: J.M. Butler

Objectives

To discharge federal responsibilities for the implementation and evaluation of Forestry Agreements in Newfoundland and Labrador; to facilitate the transfer of new technology into the forestry sector in the province; to implement forestry job creation programs as required.

Achievements Current Year

Continued management responsibilities for the Forest Resource Development Agreement. Approximately $13.8 million was spent under the Agreement's three programs. To date $36.4 million has been spent.

The Forest Management Information System was maintained. An interim evaluation was completed, as well as a technical audit of selected silviculture projects.

Technology transfer continued, particularly in areas of silviculture, forest products development, access roads construction and forest inventory.

Monitoring of various FRDA silvculture activities continued throughout the Province this past year.

Goals for 1989-90

Continue management and evaluation responsibilities for FRDA. Approximately $14.8 million will be spent on intensive forest management activities, operational research and development, and Agreement administration, communication and evaluation. Continue to assist in the transfer of technology from outside Newfoundland and participate in forestry employment development programs as required.

List of Studies

Agreement implementation and technology transfer
Leader: J.M. Butler

ECONOMICS

Economics Advisory and Consultation Services

Project 1333
Economics Advisory and Consultation Services
Project Leader: G.R. Milne

Objectives

The project's objectives are to provide advice and consultation in the area of policy, planning and economics in support of ongoing programs in forest management, research, and development. Primary clients of the project include internal Forestry Canada (ForCan) managers and scientists, external government agencies such as the Provincial Department of Forestry and Agriculture, and the forest industry. Secondary clients include Memorial University, the Fisher Institute, and the general public.

Achievements Current Year

With planning, Delphi survey and follow-up workshop were used to solicit input on strategic forest sector issues and potential ForCan - NLR initiatives in research. A first draft of a regional strategic plan was prepared. A computerized operational planning system was created. In forestry development, several forestry proposals from ACOA were reviewed. A first draft of the interim evaluation report for the Forest Resource Development Agreement (FRDA) was received on schedule from external consultants.

Goals for 1989-90

The primary goals for 1989-90 include publication of the ForCan-NLR strategic plan, and completion of the Region's first operational plan. Also, a final interim evaluation report of the FRDA will be approved. A regional data base of forest industry and resource statistics will be developed and a report published. Other advisory and consultation services will be provided upon request from clients.

Economic Analysis

Project 1334
Economic Analysis
Project Leaders: G.R. Milne, P.M. Trelawny

Objectives

The objective of this project is to undertake economic research on specific forest resource and industry problems and opportunities within the region. The research results will provide information to government and industry for use in policy formulation relating to resource and industrial development. In addition, the economists provide research support to the National Forest Economic Program (NFEP).

Achievements Current Year

At the regional level, economic studies of the sawmill and planing mill industry, and converted wood products industry were initiated. A sample survey of 275 sawmills and planing mills, and a census survey of 60 converted wood products firms were completed. In addition, preliminary work on the development of a regional input-output model was undertaken. Three short-term studies relating to the forest resource were conducted and reports published. For the NFEP, support for the study on Canada's timber supply continued. The synopsis report of Newfoundland's timber supply/demand outlook was completed and revised. Also, a first draft of a chapter for the national report, on the subject of emerging timber supply/demand issues, opportunities, and problems, was initiated.

Goals for 1989-90

The primary goals of this project include completion of a survey to develop estimates of lumber imports and consumption in Newfoundland. Data from the sawmill and planing mill, and converted wood products surveys will be analyzed and reports published. A final draft of the chapter for the NFEP national timber supply study will be completed. Information on major non-timber values will be collected from published sources and a draft report written. Longer term project direction will be defined in view of the ForCan - NLR strategic plan.

COMMUNICATIONS

Communications

Project 1241
Communications
Project Leader: D.R. Rex

Objectives

To implement a systematic approach to solicit client and other publics' input into regional programs and to raise awareness of these programs through an improved information transfer process.

Achievements Current Year

Communications activities in support of the Canada-Newfoundland Forest Resource Development Agreement (FRDA) dominated fiscal year 1988-89. Highlighting the FRDA support was the production of a resource calendar which utilized the talents of local artists. Advertising was also a significant aspect of the program as was the design, production and distribution of promotional items at various venues. Activities in support of the region's "A" base program were highlighted by ongoing improvements and modifications to the publishing process. The newsletter, "Woody Points" was upgraded aesthetically, and mailing lists were reviewed and amended. Logistical and technical support was provided to a number of technology transfer initiatives of both research programs and National Forest Week (which received full participation from regional staff) was coordinated by the Communications group. Support to headquarters, Minister's Office and cooperating agencies was provided on an as required basis.

National Forest Week 1989, Stephenville, NF.

Goals for 1989-90

To increase efforts on processes to assess and evaluate wants, needs, perceptions and understanding of regional programs. To assume a greater leadership role in coordinating an ever expanding public awareness program in cooperation with other sector organizations.

List of Studies

Communications management
Leader: D.R. Rex

Advertising
Leader: H.M. Dunphy

Publishing
Leader: D.R. Rex

Media monitoring
Leader: H.M. Dunphy

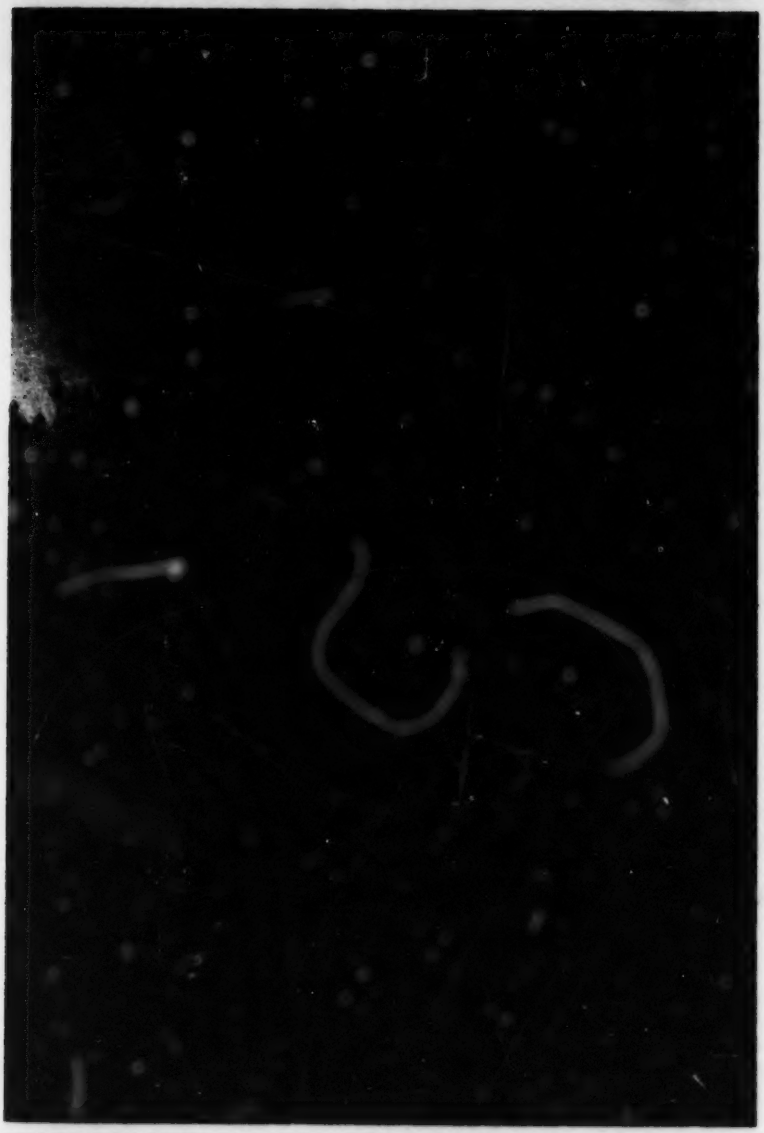
Public opinion research and planning
Leader: D.R. Rex

Public relations/inquiries
Leaders: D.R. Rex, H.M. Dunphy

Audio visuals, exhibits, graphics
Leader: H.M. Dunphy

Employee communications
Leader: D.R. Rex

Communications training
Leader: D.R. Rex



GENERAL RESEARCH SUPPORT SERVICES

General Research Support

Project 2251
General Research Support
Project Leaders: R.S. van Nostrand, J. Hudak

Objectives

To provide efficient and high quality support services to meet the needs of the research and development program of the Newfoundland and Labrador Region.

Achievements Current Year

Seed and Planting Stock Service - Cuttings were produced for the *Salix* energy plantation as well as planting stock of eastern larch for genetic research.

Chemical and Physical Analysis Laboratory - Computerization of many functions was significantly improved to speed the return of analysis data to researchers.

Botanical Herbarium - Curatorial services continued as did cooperation with other herbaria in Canada.

Greenhouse - General services continued to be provided to researchers. In addition the roof venting system was rebuilt to improve the reliability of the temperature control system.

Computer Services - In addition to providing improved software for data analysis, a communications system was installed allowing easier access to the VAX computer, resulting in more people using the system. Additional training was provided, and several computer hardware added to benefit research.

Mycological Herbarium - General herbarium services were provided to staff of the Region, and the number of specimens in the herbarium increased in 1988. Two diseases, new to Newfoundland, were collected and added, as well as host records for one disease. The extension service to the community continued.

Insect Reference Collection - General research support continued by rearing many insect samples to the identification stage, to rear for parasites or insect-diseases, or other research data. The size of the reference collection continued to expand, and material was provided for public displays. The extension service to the community continued.

Goals for 1989-90

To continue to ensure adequate data processing service, software development, training, etc. to professionl staff of the Region, and to update the graphic capabilities. To continue identification of forest insect and diseases for the Insect and Disease Survey and professional staff. To improve the reference material available for study and in support of research activities. To continue to increase the slide collection of forest pests, and to improve various types of display material. To maintain a research nursery and provide planting stock for research plantations. To conduct chemical and

physical soil and related vegetation analyses in support of research studies. To maintain and improve a comprehensive botanical herbarium of the Newfoundland and Labrador Region. To provide a modern, well-maintained and reliable greenhouse facility for conducting scientific studies.

List of Studies

Seed and planting stock supply service
Leader: A.W. Robertson

Chemical and physical analyses laboratory
Leader: D.G. Trenholm

Botanical herbarium
Leader: S.M. Morgan

Greenhouse facility
Leader: G.J. Mills

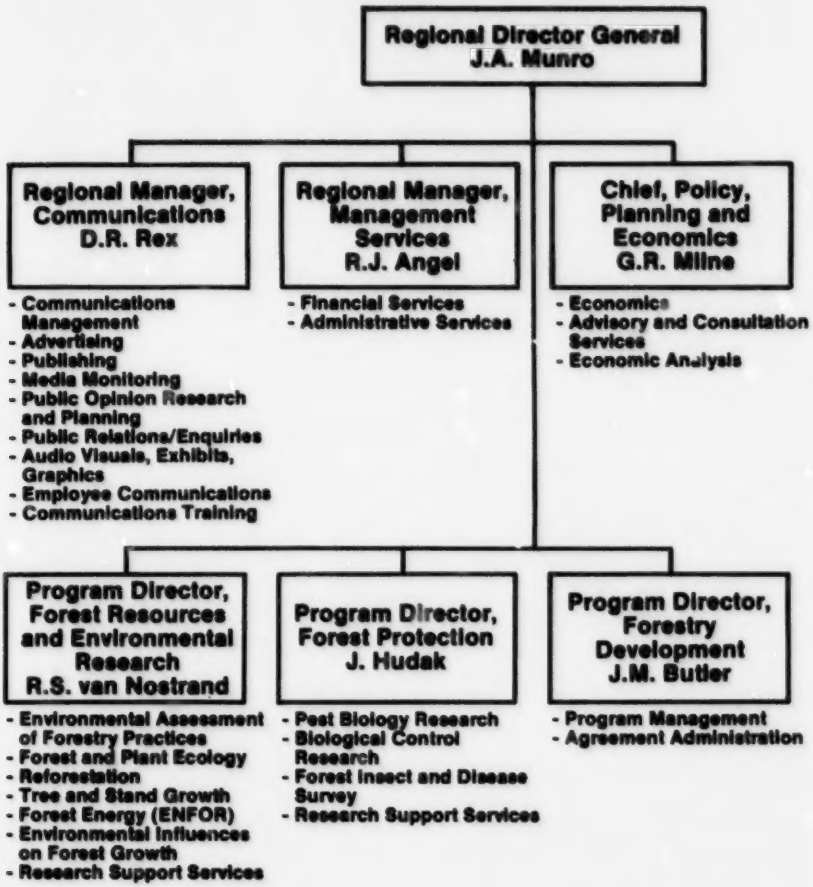
Computer services
Leader: R.G. Thompson

Mycological herbarium
Leader: G.C. Carew

Insect reference collection
Leader: K.E. Pardy

APPENDICES

Forestry Canada
Newfoundland and Labrador Region
Program Organization



STAFF LIST AND ORGANIZATION 1988-89

Regional Director General - Dr. J.A. Munro Secretary - E.E. Manuel

FOREST RESOURCES AND ENVIRONMENTAL RESEARCH

Program Director - R.S. van Nostrand

Forest and Plant Ecology - Site/Succession	W.J. Meades A.R. van Kesteren
-Soils/Autoecology	B.A. Roberts
-Wetlands	E.D. Wells S.M. Morgan
Environmental Assessment of Forestry Practices	I.D. Thompson
-Impact Assessment	W.J. Curran
Tree and Stand Growth - Ecophysiology/ Stand Modelling	M.B. Lavigne J.G. Donnelly
-Stand Development	P.F. Newton L. May
-Mensuration/Biomass	Vacant
Reforestation - Site Preparation/Stand Establishment	B.D. Titus V.D. Chaffey
-Tree Improvement/Genetics	A.J. Mosseler P.T. Tricco
Environmental Influences on Forest Growth -Biometerology	A.W. Robertson C.T. French
Forest Energy - ENFOR	R.S. van Nostrand
Research Support Services - Chemical and Physical Analysis Laboratory	D.G. Trenholm E.M. Pike G. Waterman
-Herbarium	S.M. Morgan
-Nursery Services	A.W. Robertson
-Greenhouse/Special Projects	G.J. Mills

FOREST PROTECTION RESEARCH

Program Director — Dr. J. Hudak

Pest Biology Research - Damage and Impact	A.G. Raske J.D. Rowe
-Cone Seed and Plantation Pests	R.J. West D.S. Durling
-Insect Populations	E.J. Dobesberger J. Carter
-Wood Deterioration and Decay	G.R. Warren J.P. Meades A.L. Fudge
-Bark Beetles	W.W. Bowers J.W. Marshall
Biological Control Research	P.L. Dixon K.P. Lim L. Oldford
Forest Insect and Disease Survey	L.J. Clarke E.C. Banfield W.J. Sutton D.S. O'Brien D.M. Stone
Research Support Service - Computer and Statistical Analysis	R.G. Thompson B.E. Galloway
-Mycology Herbarium	G.C. Carew
-Insect Reference Collection	K.E. Pardy

FORESTRY DEVELOPMENT

Program Director - J.M. Butler

Senior Development Officer	Vacant
Forest Development Officer	W.L. Alexander
Forest Development Officer	L.R. West
Secretary	M.A. Grandy

ECONOMICS

Chief, Policy Planning and Economics	G.R. Milne
Economics Analysis	P.M. Trelawny

COMMUNICATIONS

Regional Manager - D.R. Rex

Information Officer	H.M. Dunphy*
Public Information (FRDA)	P.L. Libbey (term)
Information Clerk	Vacant

MANAGEMENT SERVICES

Regional Manager - R.J. Angel

Finance	W.F. Walsh C.G. Prior E.C. Higdon M.A. Martin
Purchasing	F.L. Bannister J.J. Healey
Personnel	J.A. Macfarlane
Library	C.E. Philpott
Central Registry	L.J. Fennelly
Office Services	M.F. Gillingham H.M. Dunphy J.H. Rockwood
Field Station Facilities	W.V. Bonnell

* Temporarily assigned to communications

*Information Officer

CONTRACTS 1988-89

Contract No. and Name	Title	Total $'s Paid out
ENFOR		
Olk24-7-0166 4408-664-2241-3403-8464 D.B. Pike	To provide computer support services for the Forcyte Immulation Model	$24,000.00
Olk24-8-0057 4408-664-2241-3403-0440 Northland Associates Ltd.	Calibration of the Forcyte Growth Model	15,000.00
Olk24-7-0158 4408-664-2241-3402-0440 Highlands Contracting Ltd.	Establishment and Maintenance of Experimental Energy Plantation	50,000.00
Olk24-8-0014 4408-664-2241-3402-0440 Delta T Documents	Biometeorological Research. Field testing of two energy balance measurement systems	5,591.07
Olk24-7-0131 4408-664-2241-3402-0440 Delta T Documents	Construct & deliver energy balance measuring system (1987-88 Contract)	2,673.58
FRDA		
Olk24-7-0157 4491-662-3242-1207-8489 Priscilla Libbey	To implement and facilitate pre-planned communication projects & related activities associated with ForCan Reg. Com. Program.	24,184.82
Olk24-8-0050 4491-662-3241-1101-8447 G. Veitch	Monitor & administer the Can. Nfld. For. Res. Dvlp. Agreement in accordance with App.A.	33,542.68
Olk24-8-0044 4491-662-3241-1102-8444 Bruce Schooley	Dvlp. Mgmt. Inf. System (DEVMIS) enhancement, analysis and report	20,412.00
DVLP		
Olk24-7-0159 4471-735-3231-1100-1054 Azim Mallik (Trust Acct)	Study of Kalmia angustifolia-softwood tree interaction. (contract cancelled 31 July '88)	24,891.98
O&M		
Olk24-8-0048 4408-661-2214-4301-8440 Don MacDonald	To provide stat. assistance and advice reanalysis of data and inter. of results of Peatland Forestry Studies	1,500.00

NEWFOUNDLAND FORESTRY CENTRE
EXPENDITURES ($000) 1988-89

Program Areas	PY	Salaries	Development Agreement	Development Agreement O&M	Challenge '88	ENFOR	O&M	Capital	Totals
Management	2.0	101.0					27.8		128.8
Administration	15.38	438.1					281.5	490.5	1,210.1
Forest Resources	21.24	936.1			31.8	107.3	173.0		1,248.2
Forest Protection	24.92	1,007.3			25.5		244.9		1,277.7
Forest Development	4.0	179.4	9,196.1	223.4			33.3		9,632.2
Economics	2.0	97.7					8.4		106.1
Communications	1.63	63.8					55.4		119.2
Total	71.17	2,823.4	9,196.1	223.4	57.3	107.3	824.3	490.5	13,722.3

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